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Historical building information modelling (HBIM) integration with environmental analysis for green rating systems

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REVIEW

Historical Building Information Modelling (HBIM) Integration With Environmental Analysis for Green Rating Systems

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Abstract

Egypt's heritage buildings conservation faces many problems, starting from the stages of restoration of the heritage building to the operation phase of the building. With the growing trend in Egypt to preserve heritage and the trend towards sustainability, the need for a strong management tool that helps to achieve the best performance of the heritage building without compromising its basic form is essential. The term green heritage has appeared recently in Egypt and multiple attempts to achieve sustainability in heritage buildings, so the complex part of the study is the absence of a documentation tool to help for sustainable heritage preservation. This research aim is trying to focus on studying the integration between historical building information modelling (HBIM) technologies and environmental analysis on heritage buildings for achieving sustainable heritage. The research was based on an analytical study of green building rating systems that contribute to the sustainability of heritage and explain the importance of HBIM technology as a new tool to help in the process of documenting heritage buildings and then a study of international examples which applied HBIM on heritage buildings for the approach of sustainability. This study suggested a frame work for preparing sustainable heritage buildings conserved by using HBIM methodology.

Keywords: GBRSs for heritage, Green heritage, HBIM and Sustainability, HBIM technology, Heritage conservation

1. Introduction

Egypt's heritage buildings, especially those of high significance, are deteriorating as a result of neglect, lack of funding and occasional maintenance. The majority of conservation efforts for historic buildings in Egypt do not include any techniques. The structures which have more energy-efficiency and environment-friendly helps throughout the repair process or making it more effective during the operating phase, otherwise, failure or lack of outcomes leads to risking the objectives and sustainability of the entire conservation strategy. The development of heritage buildings has incorporated sustainable building principles while honouring their heritage values and distinctive character traits, which has contributed to sustainable development.

2. Research problem

Heritage buildings suffer from a lack of interest in them and face various difficulties in all stages of their restoration and preservation, so the research problem is.

(1) The lack of sustainable preservation of heritage, which led to the destruction of many of them and their non-survival.
(2) The difficulty of documenting some of these buildings because they need high technologies to maintain them.
(3) The lack of modern tools and technology that facilitate the sustainable preservation of heritage

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buildings, especially that heritage buildings are existing buildings that need modern technologies to deal with them, unlike new construction buildings.

3. Research methodology

The research methodology was divided into two parts:

Part one, the theoretical study.

(1) Clarifying the research problem and attempts at sustainable heritage preservation.
(2) A study of the relationship of green building evaluation systems with heritage buildings.
(3) A study of the use of the methodology of historical building information modeling system-s(HBIM) for heritage preservation.
(4) Reviewing the possibility of integrating green assessment and environmental analysis systems with historical building information modeling to obtain a sustainable heritage building, citing the Italian green building council for historic buildings (GBC) system as a tool for evaluating any sustainable heritage building.

Part two, the analytical study:

The analytical study depended on four examples of heritage buildings that applied the system of historical building information modeling systems to obtain a sustainable heritage building, the analysis was based on.

(1) The HBIM methodology used in dealing with the building, starting from the laser scanning stage and collecting information, then the modeling stage, and finally the data management stage.
(2) A study of the most important environmental analyzes carried out on the building in integration with the HBIM model.

The results summarized a three stages frame work of how to deal with any heritage building to obtain sustainable preservation.

4. Green heritage integration

As a result of worldwide discussions and meetings, sustainability was initially founded on three pillars the economic, social, and environmental concerns which has developed through time into a more complex and holistic concept, the Johannesburg Earth Summit in 2002 and the World Summit of Local and Regional Leaders in 2010, respectively agreed that the culture must be adopted as the fourth pillar of the sustainable development. Despite this, historical and cultural dimensions of sustainable development goals were downplayed (Bandarin, 2012). The five strategies of integrated design, life-cycle assessment, operation, embodied energy and durability of building materials, assemblies, construction, demolition waste management and hazardous material mitigation are used to the historical conservation integration and green concept (Fig. 1).

4.1. Green heritage rating systems tools

Green rating methods help in assessing new and existing building environmental performance. They described how the buildings are environmentally responsible by indicating the extent green components that have been incorporated and which sustainable concepts and practices have been used (Nguyen, 2011).

Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM (, GREEN STAR, and other rating systems are examples of these; however, each of them has its unique assessment characteristics that come from its local setting. Furthermore, none of the rating systems gives a comprehensive guidance for decision makers to select

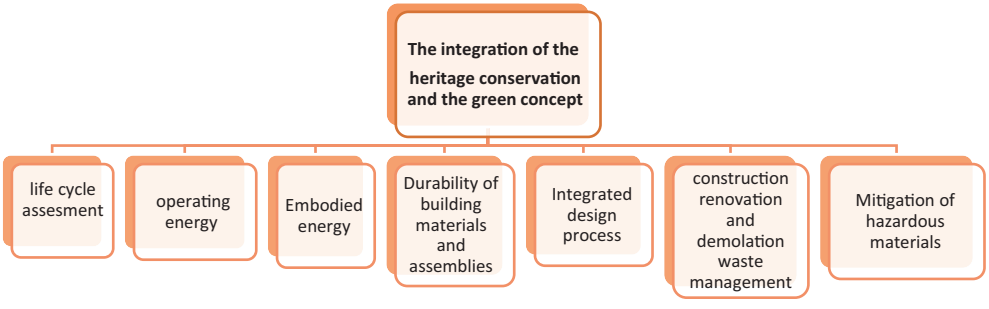

Fig. 1. The integration of the heritage conservation and the green concept (Foda, 2016).

the best inexpensive rehabilitation choices while considering the sustainability of the buildings. Although, there is a lack of detailed rating systems that might analyse heritage building aspects and support facility managers in their decisions on restoration (Al-Sakkaf et al., 2020).

Table 1 is a comparison between the international rating systems related to existing buildings which show that Green building council for historic buildings (GBC HB) Italy is the most specified rating system tool in heritage buildings so it will be the focus analysis example which was rating by it.

5. HBIM for heritage building conservation

According to (Dore, 2015), Building information modelling (BIM) software is used in the Historic Building Information Modelling (HBIM) system to model historic buildings from laser scan and photogrammetric data. For (Oreni, 2014), An option for three-dimensional parametric representation is HBIM, which enables users to handle data about old architectural components and create models. within a common software environment (IFC, Industry Foundation Classes and gbXML, green Building XML). The historic fabric that already exists is depicted using high-quality digital survey records in BIM, which also makes it possible to explore and thoroughly analysing the suggested modifications in various contexts. BIM offers a framework for collaborative working practices and the sharing of coordinated datasets across a team of experts from different fields, which is great for management, conservation, and research. BIM procedures can be used to guarantee the development of a trustworthy information base about a historical asset. A historical asset, if preserved Information modelling is a powerful asset management and decision-making tool during all of its life cycle (Antonopoulou, 2017).

5.1. BIM and HBIM different uses

BIM level of details are frequently understood to refer to a level of detail as opposed to a degree of development. A project's semantics develop at several levels of development (LODs), which are divided into five categories and numbered from LOD100 to LOD500 (Castellano-Roman, 2019). LOD400 and LOD500 relate to a level of development connected with the sophisticated documentation of the project, achieving the final character of an as-built, while LOD100, LOD200, and LOD300 refer to conceptual, schematic, and detailed designs, respectively (Buyuksalih, 2013).

The semantics of heritage management are represented by LOK knowledge levels, which are

Table 1. Comparison of the international green rating systems related to existing buildings ref.(researchers).

	LEED	BREEAM	Homestar	Green star	BEAM plus	GPRS	GBC Italy
Benefits of the rating system	offers a cost-effective green buildings and is accessible for almost all building types.	used to create master plans for infrastructure, projects, and structures	a rating system for evaluating the sustainability, and health of homes	hundreds of sustainably constructed houses, buildings, and communities all around the country have been certified	Enhancing the health and wellness of building tenants is one of its main objectives.	Green Pyramid Rating System. It assesses environmental qualifications.	the first and only rating tool assessing the level of sustainability of conservation-related interventions on historic buildings
Last update	2013	2012	2010	2017	2017	2017	2015
The origin country	USA	UK	New Zealand	Australia	Hong Kong	Egypt	Italy
The type of rating system	International	International	local	international	local	Local	local
New construction scheme	√	√	√	√	√	√	×
Rating existing buildings	√LEED BD + C LEED O + M	√ (BREEAM Refurbishment and Fit-out)	×	√ (Green Star Performance v1.2)	√ (BEAM Plus EB V2.0)	√ GPRS V2-NB	(GBC HB)
Has heritage context considerations	Has high context for heritage buildings	provide a more appropriate version of BREEAM for heritage buildings	×	Culture, heritage and identity	Embraces existing buildings of all ages	Innovation and added value aspect	GBC Italia elaborated a specific rating system for certification of historical buildings

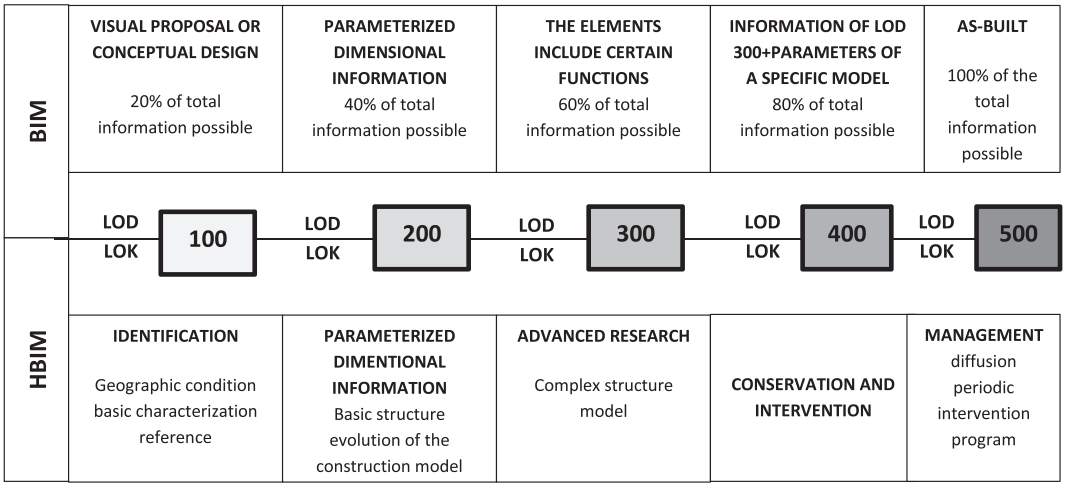

Fig. 2. BIM and HBIM different uses.

categorised from LOK100 to LOK500 (Castellano-Roman, 2019). LOK300 provides more detail about the characterization of graphic entities to the point of being able to show the results of specialised investigations carried out using archaeological methodology. LOK100 is associated with the identification of the heritage asset and its basic characterization. LOK200 enables the graphic charact erization and sufficient information for the development of actions related to the legal protection of the asset and its strategic planning.

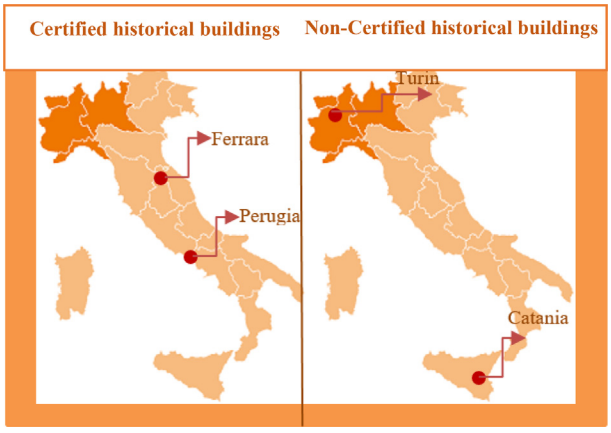

Fig. 4. Case studies location in Italy.

6. HBIM methodology

Historic England (Sofia Antonopoulou, July 2017) issued detailed and understandable guidance for

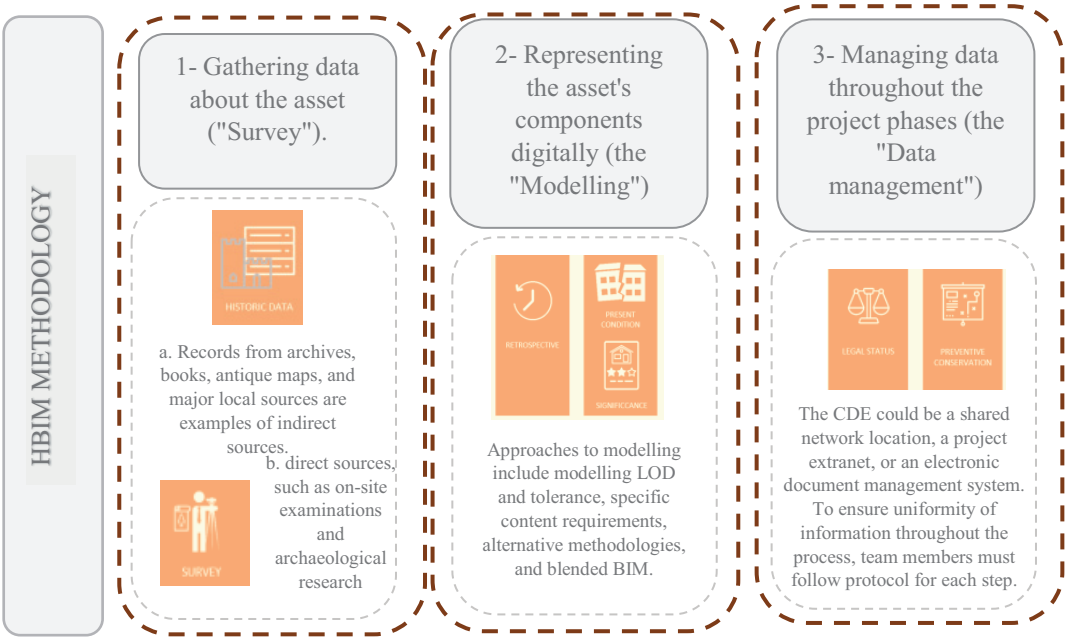

Fig. 3. HBIM methodology.

Fig. 5. On the right ov er view of the stables source: Green building council Italia and the left picture is building layout. Ref (Italia, n.d.).

Fig. 6. Laser scanner survey Ref. Piselli (Piselli, 2020a, b).

Fig. 7. 3D view of the architectural model (Piselli, n.d.).

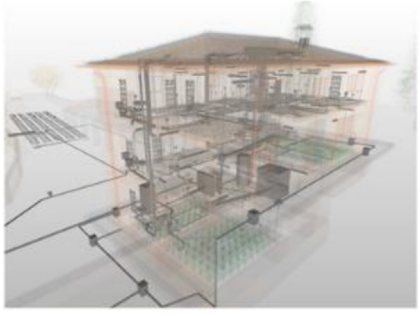

Fig. 8. 3D view of the multidisciplinary (Mechanical–Electrical–Plumbing (MEP) model (Piselli, 2020a, b).

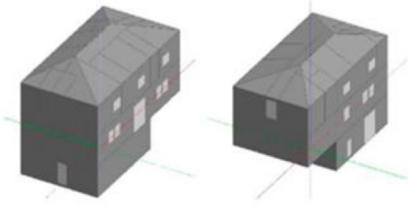

Fig. 9. Simplified Revit model to be imported in Design Builder Ref (Piselli, n.d.).

Fig. 10. Revit add-in application for structural performance and human-centric comfort monitoring in HBIM.

heritage management in a BIM context in 2017 and it is briefly discussed in the following paragraphs. The main three components of the process are being shown visually in Fig. 2. Gathering data about the asset (the 'Survey'), representing the asset's components digitally (the 'Modeling'), and managing data throughout the project phases (the 'Data management') (Fig. 3).

7. Heritage building information modelling (HBIM) and heritage sustainability

A detailed strategy is necessary for a LEED certification project to be effective, as well as integrated planning and coordination. The procedure is set up in the form of a continuous cycle of programming, revision, analysis, and correction. Extraction and

Fig. 11. The right picture is overview of The historic Palace Gulinelli and on the left is the building layout Ref (Ercole, 2018).

Fig. 12. Laser scanner survey of palace Guilinelli (Artioli, n.d.).

Fig. 13. Revit model of the palace (Artioli, n.d.).

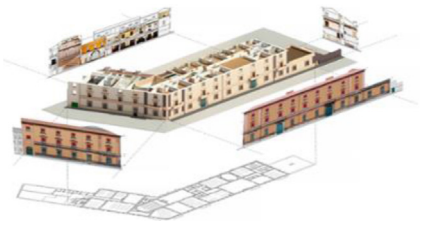

Fig. 14. BIM model exploded view (Artioli, n.d.).

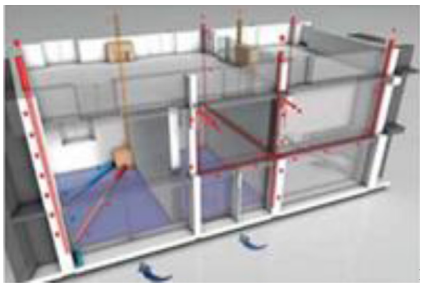

Fig. 15. BIM modelling used to renovate the Victorian Age conditioning system, where feed pipes are marked in red and return pipes in yellow (Italy, 2017).

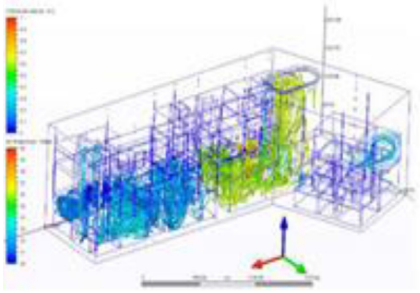

Fig. 16. Dynamic simulation.

retrieval of essential data necessitates a great deal of iterative labour, cooperation of various stakeholders and frequently contradictory sources. BIM is a tool used overall for project management and for repetitive data collecting, design, simulation, and verification processes, thus viewed as a tool for process optimization. For heritage buildings there are a lot of problems face the project stockholders to achieve sustainable restoration and get a building certification. So the research studies specialized in rating system of historical buildings are made to study the link between heritage building rating systems and using historical building information modelling analysis tools.

7.1. GBC HB Italy certification

Is the Italian GBC rating system for historic buildings in Italy which was designed based on the standards of THE LEED but to be ***specialized in Italy's historical buildings***, it has certified many buildings in Italy, some of them used HBIM model for building conservation and environmental analysis even building maintenance phase. This system depends on the existence of an identification card that no building can apply for the evaluation without obtaining it. It is being done through the existence of organized documents on the

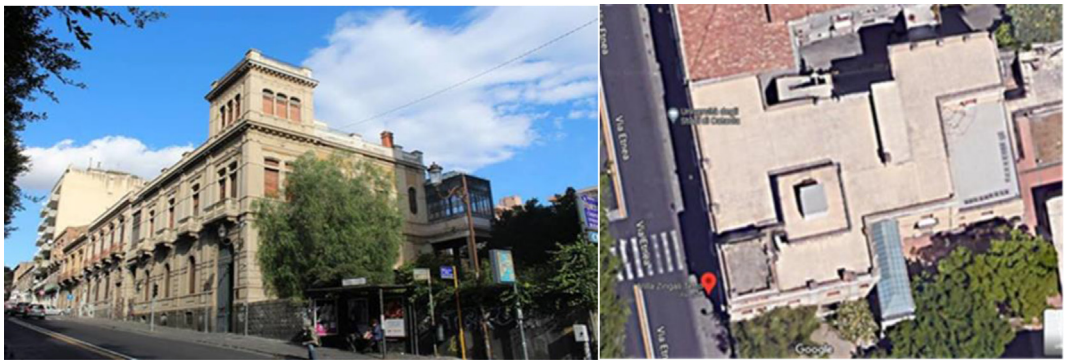

Fig. 17. The right picture is overview of Villa Zingali Tetto and on the left is the building layout Ref. (La Russa, n.d.).

Fig. 18. Laser scanner survey Ref (La Russa, 2020).

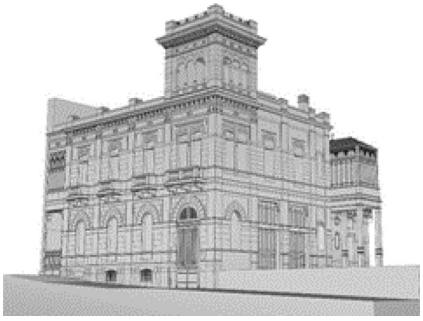

Fig. 19. HBIM model Ref (La Russa, 2020).

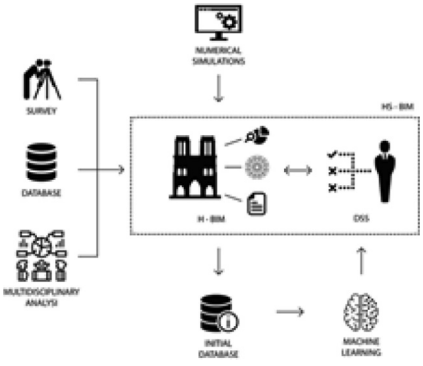

Fig. 20. HBIM workflow Ref. (La Russa, 2020).

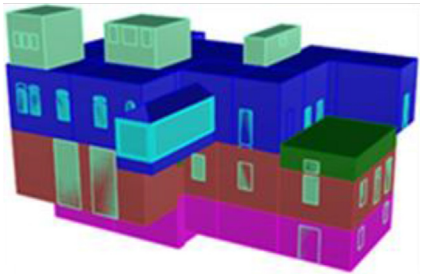

Fig. 21. The simplified three-dimensional model of the villa for energy simulation. Ref (La Russa, 2020).

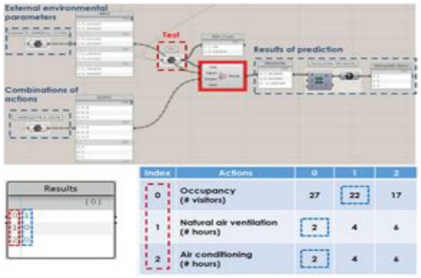

Fig. 22. DSS code in Grasshopper and results of the simulation. Ref (La Russa, 2020).

management of restoration and modernization work in the heritage building, which made the ***HBIM*** tool have a key role in facilitating the acquisition of this card.

7.2. Analytical examples for heritage buildings in Italy used HBIM analysis tools and methodology

In this part of the research, the researchers choose to analyse examples of four heritage buildings located in Italy used HBIM methodology for

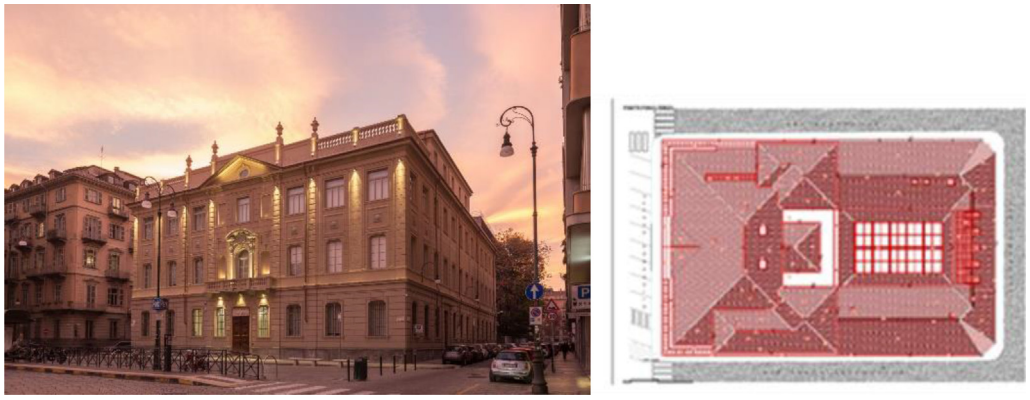

Fig. 23. The right picture is overview of Villa Zingali Tetto and on the lett is the building lay out Ref. Srl (Srl, 2018).

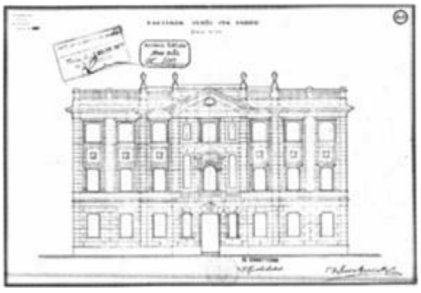

Fig. 24. 2D documents Ref. Srl (Srl, 2018).

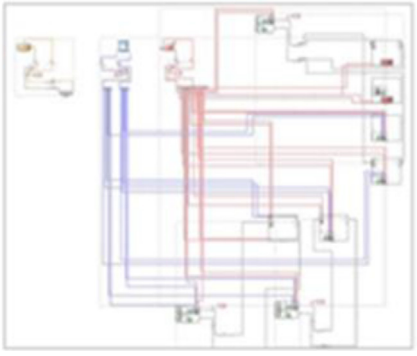

Fig. 26. Hvac design simulation Ref. Srl (Srl, 2018).

Fig. 25. BIM model on Revit Ref (Alberto, n.d.).

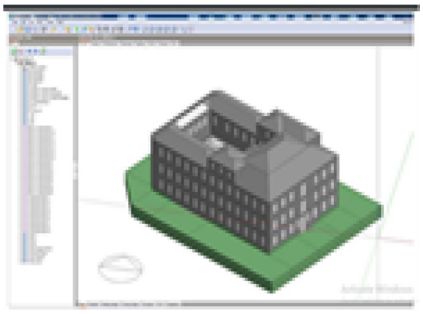

Fig. 27. Calculation software used Energy Plus and Design Builder Ref. (Srl, 2018).

sustainable analysis on the buildings to achieve sustainable credits on it so examples are divided in two sections: first, certified historical buildings: It is the historical buildings which has applied HBIM methodology and used it for environmental documents to achieve certification. Second, non-certified historical buildings: It's an examples of historical buildings which have applied environmental solution by implementing HBIM methodology depending on sustainable protocols but still not certified (Fig. 4, Tables 2–5).

Table 2. Case study 1 analysis: The stables of the Rocca di Sant'Apollinare (PG).

Project name	Case study (1) The stables of the Rocca di Sant'Apollinare (PG)					
Description of the project	Year of the construction	The year of renovation	The project location	The project area	The original use	Current use
	10th century	2018	Perugia, Italy	385 square meters	The Stables of fortress of a local noble family in Rocca di Sant'Apollinare.	The Stables became some offices of CIRIAF— CRB research centers.
project picture	Fig. 5					
HBIM methodology	**1.survey**		**2. Modelling**		**3.Data management**	
	Using laser scanning, the building's data was gath ered. According to 2D documentation, the structure has a basement floor, two stories, and is roughly 140 m2 which is the net area sur veyed Piselli (Piselli, 2020a, b) Fig. 6		The Revit platform for BIM design authoring was used to create the archi tectural model of the case study building (Autodesk) (Piselli, 2020a, b) (Fig. 7)		Utilizing the manage section and the manage links command, the files of the various models are connected together. Piselli (Piselli, 2020a, b) (Fig. 8)	
HBIM sustainable approach	Internal Environmental Quality		The Energy Plus tool's dynamic energy simulation allows for the definition of the building's energy needs under various climatic boundary conditions, occupancy profiles, etc. Romanelli (Romanelli, 2019) (Fig. 9)			
	Energy saving		A building energy performance simulation in Energy Plus was used to assess the potential energy savings from the refit of the gas boiler with a geothermal system in terms of both economics and environmental effects. Romanelli (Romanelli, 2019) (Fig. 10)			
	Analysis soft wares		-Revit analysis -importing the gbXML -Design builder -Energy plus			

Table 3. Case study 2 analysis: The historic palace Guilinelli.

Project name	Case study (2) The historic Palace Gulinelli					
Description of the project	Year of the construction	The year of renovation	The project location	The project area	The original use	Current use
	1844	2015	Ferrara, Italy	835 square meters	Historical palace.	'Smiling' international school
project picture	(Fig. 11)					
HBIM methodology	1. Survey		2. Modelling		3. Data management	
	Laser scanner technology was used to survey the building. A 3D point cloud of the entire survey is produced by the laser scanner. (Artioli, n.d.) (Fig. 12)		The programme made it possible to create a virtual project that included all of the building's structural elements and materials in their actual dimensions. (Artioli, n.d.) (Fig. 13)		In reality, the integrated design enables simultaneous, controlled data updates, management, and extraction from a single model at any moment. (Artioli, n.d.) (Fig. 14)	
HBIM sustainable approach	Sustainability of the site		The achievement of the score in the category of 'Sustainability of the site' was made possible by effective management of the available building site area. Italy (Italy, 2017) (Fig. 15)			
	Energy and Atmosphere		The design changes have produced good results for the building's energy requalification, as evidenced by the achievement of an A4 energy class with a consumption of 76.72 kW/h square meters. Italy (Italy, 2017) (Fig. 16)			
	Internal Environmental Quality		To ensure adequate air exchange, the chapter assesses the requirements for comfort and indoor air quality in many different ways.			
	Analysis soft wares		-Design builder-Revit model simulation			

Table 4. Case study 3 analysis: Villa Zingali Tetto, Italy.

Project name	Case study (3) Villa Zingali Tetto, Italy					
Description of the project	Year of the construction	The year of renovation	The project location	The project area	The original use	Current use
	1930	2020	Catania, Sicily, Italy	4500 m square	The villa was inhabited by the lawyer Zingali Tetto	exhibition space of the Department of Engineering and Architecture of the University of Catania.
project picture	(Fig. 17)					
HBIM methodology	1. Survey Detailed analysis of the historical building's construction methods by laser scanning and photogrammetric survey, as well as 3D digitali zation of the historical building. La Russa (La Russa, 2020) (Fig. 18)		2. Modelling HBIM modelling of the entire struc ture while accounting for high LOD for the analyzed museum rooms. La Russa (La Russa, 2020) (Fig. 19)		3. Data management collection of meteorological information from the nearby climate station and storing it enhancement of the thermo-technical information in the visual programming language VPL environment and the NURBS model's simplicity of the H-BIM model (La Russa, 2020) (Fig. 20)	
HBIM sustainable approach	HVAC system		The administration of the current HVAC (Heating, Ventilation, and Air Conditioning) systems was optimized by the BIM model. La Russa (La Russa, 2020) (Fig. 21)			
	Energy simulation		VPL programming tools were used to carry out the simulations. La Russa (La Russa, 2020) (Fig. 22)			
	Analysis soft wares		-VPL programming tools -Rhinoceros 6, GH (Grasshopper) and Dragonfly and Honeybee GH plugins for energy simulations.			

Table 5. Case study 4 analysis: collegio carlo alberto, Italy.

Project name	Case study (4) collegio carlo alberto, Italy					
Description of the project	Year of the construction	The year of renovation	The project location	The project area	The original use	Current use
	1866	2017	Turin, Italy	5 thousand square meters	The building was a school	later became the Faculty of Economics and Commerce of the University of Turin
project picture	(Fig. 23)					
HBIM methodology	1.survey The new Carlo Alberto is being utilised as a case study because it is the first time the framework has been applied to the renovation of a historic structure in Italy (Fig. 24)		2. Modelling Building information modelling has been created by using Revit model (Fig. 25)		3.Data management The building model integration has been used for energy simulation calculation.and for every conservation strategy in that building The project team have used the common data environment to share the file. Srl (Srl, 2018) (Fig. 26)	
HBIM sustainable approach	Energy simulation		establishing a minimal standard for increased energy efficiency for buildings and facilities in order to lessen the effects of excessive energy consumption on the economy and the environment while maintaining the building's historically and artistically significant features (Fig. 27)			
	Analysis softwares		Revit model analysis for exporting gbXML. Calculation software used- Energy Plus - Design Builder			

8. Data analysis

Table 6 is a comparison between the four case studies so the data extracted from the research case studies (Tables 2, 3, 4, 5) could arranged some steps for using HBIM methodology for any heritage building to help achieving sustainable approaches and sustainable reports for any rating systems which starts from the HBIM methodology then exporting the BIM model in to different plugins to get formal reports that could be served for any certification of sustainable rating systems.

Building Information Modelling (BIM) technology ac-cording to (Azhar and Brown, 2009), has several benefits for building environmental design and assessment. Furthermore, the integration of the Building Information Model with Performance Analysis tools significantly simplifies the frequently complex and difficult analysis. The efforts which have been made in the field of green construction to develop and exhibit integrated BIM frameworks and workflows (Horn, 2020; Naneva, 2020; Santos, 2019). Recently, there has been some research towards integrating HBIM with green heritage.

Only a few researches had looked into the link between the two techniques, HBIM and GBRSs.The building Information Modelling (BIM) is a way of maintaining critical facility design and project data in a digital format throughout the lifecycle of the building. It has been proposed as an innovative technique capable of causing a technological and procedural shift in the construction sector (Panuwatwanich, 2013). BIM provides a comprehensive, data-rich model capable of doing in-depth environmental assessments (Azhar, 2011).

According to (Krygiel, 2008), BIM can aid in the design of sustainable buildings in a variety of ways, including building orientation, building massing, daylight analysis, water harvesting, energy modelling and materials. According to (Barnes, 2009) couture's demonstration, 13 of the LEED credits can be analyzed directly using BIM.According to (Azhar, 2011), BIM technologies like as Autodesk Revit and Integrated Environmental Solutions (IES) software can assist an organization in obtaining more than 35% of the LEED points available. Ilhan (2017) reported that when BIM is linked to the BREEAM ratings system, automatic sustainability assessment is possible. As for (Wong, 2014) demonstration, BIM technology can be used to meet twenty-six (26) of the Hong Kong 'BEAM Plus' sustainable building rating system's credits. According to (Gandhi, 2014), BIM can contribute to around 90% of Green Star Australia credits. BIM software, according to (Abdelaal, 2019), can be utilized to get 76 points out of a potential 120 points on the New

Table 6. Comparison between the four case studies.

Case study name	Certified historical buildings		Non certified historical buildings	
	Case study (1) The stables of the Rocca di Sant'Apollinare (PG	Case study (2) The historic Palace Gulinelli	Case study (3) Villa Zingali Tetto, Italy	Case study (4) collegio carlo alberto, Italy
HBIM methodology	1. Survey: used laser scanner for 3D model 2. Modelling: Used BIM Revit model3. Data management: different files of the model linked to manage the building	1. Survey: used laser scanner and photogrammetry for 3D model 2. Modelling: 3D Revit model 3. exported the model to data exchange	1. Survey: through laser scanning and photogrammetric survey. 2. Modelling:by Revit model with high LOD 3. Data management: model simplified for VPL environment	1. Survey: the data collected from 2D drawings 2. Modelling: the model made by Revit programme 3. Data management: the building model was integrated to export it to sustainable calculations
HBIM sustainability	After exporting the model gbxML the model could calculate: -Energy simulation by design builder reports -HVAC loads -indoor quality environment	The Revit model used for sus tainable calculations and reports for -materials -energy simulating -dynamic simulation for indoor quality environment	The model simplified for using to calculate energy loads and dy namic simulation for calculate the average number of the building visitors	The Revit model was exported to different plugins to calculate different sustainable reports to take the building identification card

HBIM, historical building information modelling.

Table 7. Comparison of the international green rating systems and BIM integration.

	LEED	BREEAM	Homestar	Green star	BEAM Plus	GBC Italy
Could integrated with BIM	√	√	√	√	√	√
Authors examples for BIM integration	Barnes & Castrol couture (2009)/Azhar et al. (2011)/Akcay and Arditi (2017)	Ilhan and Yaman (2016)	Abdelaal et al. (2019)	Gandhi and Jupp (2014)	Wong and Kuan (2014)	Žurić (Žurić, 2019)
Achieved credits through BIM	13 credits of total LEED credits achieving more than 35% of the LEED total points.	claimed that automatic sustainability assessment can be achieved when BIM is integrated with the BREEAM rating system.	76 points of a total of 120 points of the New Zealand Homestar rating tool can be achieved using BIM software.	nearly 90% of Green Star Australia's credits can be assisted through BIM.	twenty-six (26) credits of the Hong Kong 'BEAM Plus' sustainable building rating system can be achieved using BIM technology.	It was possible to relate the information needs of GBC HB Certification to BIM information types and establish a holistic BIM approach as a result.
BIM tool	Revit	ArchiCAD	Revit	Revit	Revit	Revit
Data exchange scheme	Green Building XML (gbXML) Application Programming Interface (API) Microsoft Excel	Industry Foundation Classes (IFC)	Green Building XML (gbXML)	N/A	N/A	Industry Foundation Classes (IFC)

Zealand Homestar grading method. Many research has been conducted to demonstrate the integration of BIM and rating systems, as well as numerous studies on heritage buildings and rating tools. For GBC HB Italy it was possible to relate the information needs of GBC HB Cert ification to BIM information types and establish BIM approach as a result.

Table 7 compared between six rating systems tool. It shows the studies have made attempts to integrate BIM into the rating systems.

So through the data analysis of the four case studies and previous studies, the use of HBIM technology on heritage buildings shows its importance clearly especially with regard to the sustainability of heritage buildings, it was found that through the HBIM model, it can be exported to any plugin for sustainability calculations which will greatly facilitates obtaining a certified building rating systems.

On the other hand, the analysis helped in the assessment software and BIM data exchange that enable exporting data from the Revit model and integrating it into supported environmental analysis software such as Integrated Environmental Solutions (IES), Geographic Information System (GIS), Life cycle assessment LCA tools, and so on. Meshing and data transmission between Autodesk Revit and analytic applications are facilitated by BIM data interchange systems such as Industry Foundation Classes (IFC) and Green Building XML (gbXML). Furthermore, data communication formats limit information loss, avoid data re-entry, save time, and improve accuracy.

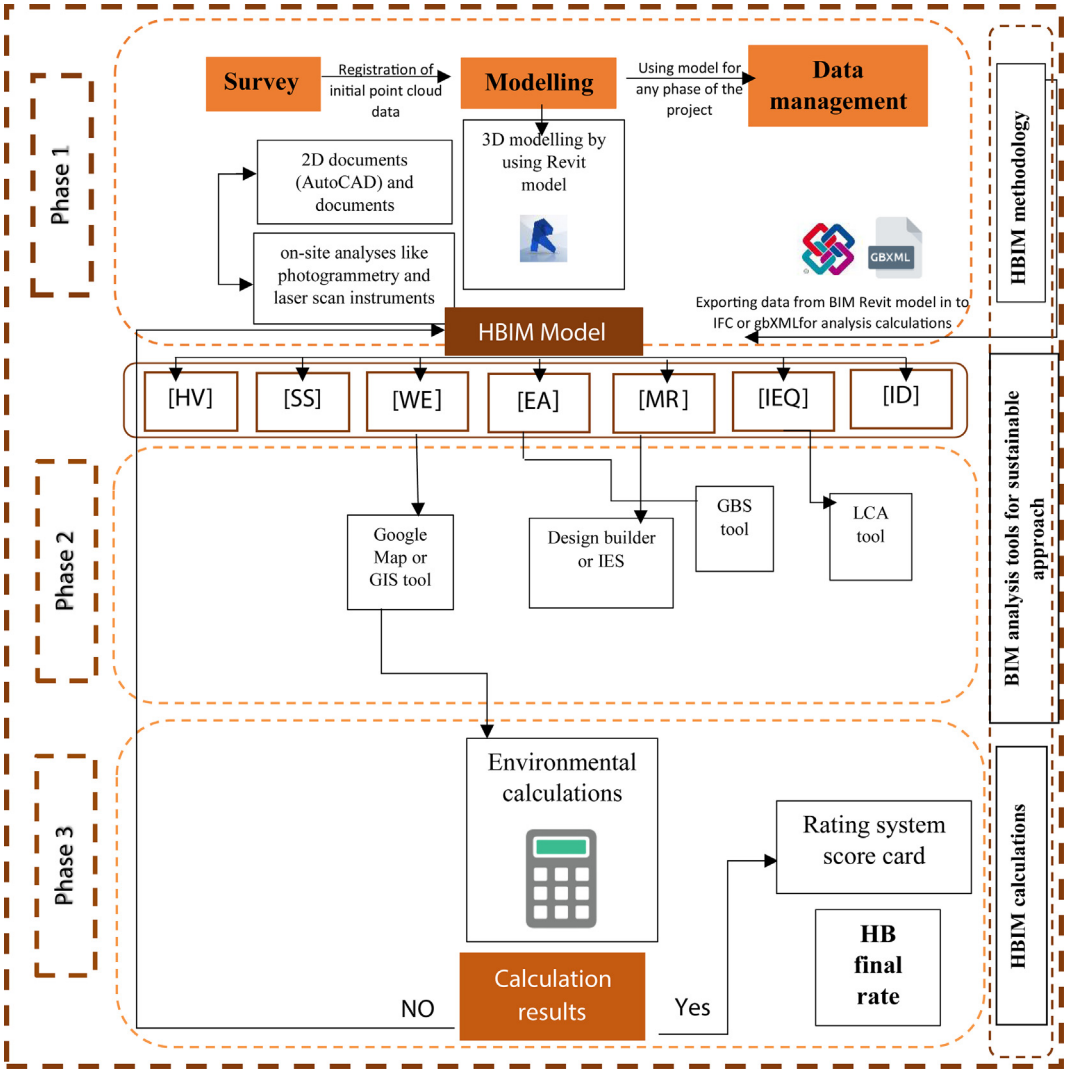

Fig. 28. Sustainable heritage conservation frame work based on HBIM tools.

9. Results

The research is organized into a six categories of the GBC HB rating system. By analyzing GBC HB Italy assessment credits for getting a frame work based on HBIM methodology to get the proposed steps for getting a sustainable heritage building.

Fig. 28 describe the suggested frame work which consists of three phases summarizing a methodology for obtaining a sustainable heritage rating system based on HBIM model.

9.1. Phase 1: HBIM methodology

First, the project team should gather all of the inputs: on-site information, building documents, regulations, and pertinent product information and using the laser scanner instruments, this step is called (survey). Then, the process of forming external database and libraries can start, controlled by the project templates and using the Common data environment (CDE) (modelling). From there, the HBIM model of the existing state is formed, using the BIM authoring tool and controlled by the authoring tool Template formed for that purpose. When the model of the existing state (Digital twin) is created, the project for the intervention can start (data management).

9.2. Phase 2: BIM analysis tools for sustainable approach

After exporting the model from Revit (gbXML) Green Building XML is the language of buildings allowing disparate building design software tools to all communicate with one another. Or (IFC) by Using the corresponding BIM tools, simulations and analysis for specific categories should be performed. They include: Design analysis, Energy analysis, LCA assessment, Cost analysis, and LEED credit assessment. The analysis results are the feedback for the HBIM model which is updated until the project meets the satisfactory level. When the final check for the credit application is confirmed, the output.

9.2.1. Historic value

Output needed is 2D drawings and photographs by using laser scanning, photogrammetry and 2D documentation.

9.2.2. Site sustainability

The architectural Revit model and site plan can be used to drive the assessment of the sustainable site category. Also Using Geographic Information System (GIS) and Google Maps, travel lengths from the building location to public transportation stops and neighborhood amenities can be determined. Extra data, such as public transportation schedules, cannot be included in a Revit model.

9.2.3. Water efficiency

The plumbing data, such as the numbers of plumbing fixtures in the structure and the size of the rainwater tank is typically included in the Revit model. Using Autodesk Green building studio GBS Water Efficiency (WE) Analysis.

9.2.4. Energy and atmosphere

The Credit can be earned by using environmental analysis tools like Integrated Environmental Solution (IES), Revit Insight and Design builder. GBS and Revit Insight are Autodesk products that works with Revit.

9.2.5. Materials and resources

BIM is an information management technology that provides information on building materials such as type, specification and quantity. It creates a ‘materials‘ database for materials certifications, eco-labels, Environmental Product Declarations (EPDs) and VOC content that can be incorporated into BIM platforms to allow for a completely automated assessment procedure for the Materials credits.

9.2.6. Indoor environmental quality

Thermal comfort, efficient space heating and natural lighting credits can all be obtained with the use of environmental analysis tools like Integrated Environmental Solution (IES).

9.3. Phase 3: environmental calculations

Every plugin and analysis tools could export environmental reports to achieve every credit. Fig. 28 shows that if the calculations of the reports are not needed for getting the credit the team could go back to HBIM model and make easily the solutions which could achieve the best results to get the credits, and if the calculations are suitable the building could take the credits.

9.4. Conclusion

This study tries to bridge the research gaps by adapting workflow for Green heritage based on the HBIM methodology for the GBRS rating system and identifying the workflow-supporting extra data, analysis tools, and data sharing protocols. So the

research clarifies The obstacles and limitation of implementing such techniques are.

(1) The integration between HBIM techniques still have some barriers to improving platform interoperability and reducing information loss.
(2) The cost of using survey tools because heritage buildings need accurate devices. The need for devices with high capabilities in the modeling stage, which increases the cost.
(3) These techniques need to educate specialists in the field of heritage, which requires time to move to the stage of starting to use them.

The conservation trends are increasing wildly therefore historical building information modelling HBIM proved the ability of this technology for the sustainable heritage conservation So, it is recommended that.

(1) The government should start providing the necessary capabilities to implement HBIM technology in the parties interested in preserving heritage.
(2) Teaching those interested in heritage HBIM technology in order to enrich their contribution to the revival of heritage.
(3) Work on developing green evaluation systems in Egypt to suit heritage buildings.
(4) Providing the necessary devices to use this technology in the bodies concerned with preserving heritage.
(5) Start to use HBIM models for heritage conservation wildly in Egypt to make a big data environment about Egyptian heritage buildings for helping the stakeholders whose interested in preserving heritage.

Authors contribution

Conception or design of the work: Ahmed ElTantawy ElMaidawy, Yasmin Mohamed abd elhameed Elkwisni (70%/30%). Data collection and tools: Ahmed ElTantawy ElMaidawy, Yasmin Mohamed abd elhameed Elkwisni (40%/60%). Data analysis and interpretation: Ahmed ElTantawy ElMaidawy, Yasmin Mohamed abd elhameed Elkwisni (30%/70%). Methodology: Ahmed ElTantawy ElMaidawy, Yasmin Mohamed abd elhameed Elkwisni (70%/30%) Drafting the article: Ahmed ElTantawy ElMaidawy, Yasmin Mohamed abd elhameed Elkwisni (50%/50%). Final approval of the version to be published: Ahmed ElTantawy ElMaidawy, Yasmin Mohamed abd elhameed Elkwisni (50%/50%).

Conflict of interest

There are no conflicts of interest.

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